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ABSTRACT

Developed in response to deficiencies in verbal and quantitative skills demonstrated by students entering New Jersey colleges and taking the New Jersey Basic Skills Placement Test, this overview is designed to help interested educators orient themselves to the important and rapidly growing field of thinking skills instruction. The Task Force on Thinking offered the following findings and recommendations. (1) If the kinds of thinking necessary for academic success are to be developed, educational institutions will have to undertake a major effort to develop the skills themselves. The type of thinking emphasized in educational institutions is more abstract, critical, systematic, and precise than the thinking characteristic of most non-school environments; therefore, academic thinking must be taught. (2) The demand that educational institutions teach thinking skills will come not only from those concerned with academic performance but also from those concerned with economic performance and effective citizenship. While educators can expect little or no improvement in the thinking skills with which students enter school, they can expect demands from outside the educational system that students be proficient in those skills when graduated. (3) Teaching these skills can be done, but the methods for teaching them must take full cognizance of the considerable difficulties inherent in that task. (4) Recommendations are presented for those who make educational policy. (5) Recommendations are made for those who construct or select instructional materials. (6) Recommendations are given for classroom teachers. Five pages of references conclude the report. (AG)

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THINKING SKILLS:
an overview

Report of the Task Force on Thinking

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Department of Higher Education

March 19, 1986

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Thinking Skills: An Overview

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PREFACE

The Basic Skills Council is an advisory body to the New Jersey Board of Higher Education. Its charge since 1977 has been to develop annually the New Jersey College Basic Skills Placement Test (NJCBSPT) and to report on both the basic skills status of New Jersey's 50,000 public college freshmen and on the effectiveness of the remedial programs in the colleges. The placement test results have repeatedly shown that the majority of our college freshmen have some difficulty with the sequential operations of an abstract nature; with organization of thoughts into a coherent essay; and with making inferences that require going beyond the recognition and repetition of what has been given.

One study in particular led to the formation of the Task Force on Thinking. Dr. Charles Pine analyzed the relationship between the higher scoring essays on the NJCBSPT and <u>each</u> individual multiple choice question in each of the Reading, Sentence Sense, Computation and Elementary Algebra subtests. Unexpectedly, there were more <u>algebra</u> questions that related to good essay scores than there were questions on <u>any</u> of the other subtests. Looking more closely, it was discovered that the algebra questions which related to good writing were predominately those that required several sequential steps to solution; in particular, the solving of linear equations. The Task Force on Thinking was subsequently formed to review the relationship of underlying thinking to basic skills performance and to put forth recommendations to educators on ways to improve the teaching of "academic" thinking.

The Task Force membership was designed to include both faculty who are currently involved in the specific teaching of thinking skills and researchers from many disciplines [including biology, cognitive psychology, computer science (artificial intelligence), history, mathematics, physics, and political science]. A year of literature reviews,

accompanied by long and lively discussions, has not only been chaired but in a prodigious effort synthesized in this report by Professor William T. Daly.

The Council gratefully acknowledges his leadership of this project as well as the contributions of Professor Lucinda S. Jassel who spent the 1985-86 academic year as a Faculty Fellow at the Department of Higher Education for this project.

Anthony D. Lutkus, Director
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March 19, 1986

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THE REASONS FOR THIS OVERVIEW

This overview is designed to help interested educators orient themselves to the important and rapidly growing field of thinking skills instruction. Specifically, we have attempted to pull together in one place much of the work currently being done in this field in such a way as to clarify its implications for education. We have undertaken this task for three reasons.

The Importance of Thinking Skills

The Task Force on Thinking was initially established by the New Jersey Basic Skills Council to help deal with a very practical problem. Large numbers of students entering New Jersey colleges and taking the New Jersey College Basic Skills Placement Test exhibited serious deficiencies in both verbal and quantitative skills. An analysis of the pattern of these deficiencies indicated that the root of the problem, and a possible basis for a solution, might lie in the area of thinking skills.

More recently, however, the concern with thinking skills, in New Jersey and in the nation, has grown far beyond this initial concern with skills deficiencies to become something of a national movement. Three factors may help to account for this growth. First, "higher order" thinking skills, as we shall define them, turn out to be inseparable from what most educators have always hoped for as the most important outcome of quality education. The capacity to extract from a series of concrete experiences the general principles which govern them all; the ability to move such abstract concepts around in our minds, and hence to see things not only as they are but also as they might be; and the resultant ability to see beyond the present to the future, and to govern our behavior in light of its likely long term consequences for ourselves and others - these are the central characteristics which have always separated truly educated people who are capable of generating ideas of their own from people who are the passive recipients of the ideas of others. They are, as a result, the highest achievement of good teachers and

the key for students to the excitement of self-motivated and self-directed learning.

Secondly, the possibilities for effective instruction in thinking skills now seem great enough to justify the considerable effort it will require. Specifically, there is now the intriguing possibility that the research efforts spawned by the current revival of concern with thinking skills may actually yield important advances in our understanding of how people think and how they might be taught to think more effectively. Finally, changes in technology and in the economy, discussed below, have called the practical importance of thinking skills to the attention of policy makers. As a result, they may be willing to support research and instructional work on thinking, beyond the normal life span of educational fads, and long enough for it to actually produce significant educational results.

In short, much of the current importance of thinking skills lies in the power of this concept to refocus our attention, with some precision, on the central and enduring concerns of education, and to do so at a time when we might be able to muster the support necessary to actually do something about some of those concerns.

The Need For An Overview

Three aspects of the current wave of feverish activity in the area of thinking skills made clear to us the need for an overview of the field. First, we seem to have rediscovered, with great fanfare, a very old idea. The idea that learning to <u>think</u> in productive ways about content materials is more important than simply committing large amounts of factual material to memory, has been proclaimed periodically from the time of Socrates to the most recent wave of "discovery" learning in the 60's and 70's. Secondly, there seems to be equally widespread consensus that, in spite of our long-standing commitment to teaching thinking, our students still do it very poorly. Finally, with these two statements - that thinking skills are important and that they are poorly developed in our students - the consensus ends.

There is a bewildering array of definitions in response to even the preliminary question of what we

mean by "thinking skills." Everyone agrees that students must develop them, but aren't; test makers claim to measure them; textbook publishers and school districts claim to teach long, and often undifferentiated, lists of them; and legislators in some states have even written them into the law. But there is very little agreement on even the preliminary question of what they are. There is, moreover, surprisingly little discussion of the nature of the obstacles that have apparently prevented effective instruction in a set of skills to which there has been such a strong and long-standing commitment among educators. Finally, there is, of course, precious little agreement as to what ought to be done about student deficiencies in thinking skills.

Such a state of creative chaos is common in fields of inquiry which are experiencing rapid growth or reorientation; it is a sign, and a cost, of vitality. But it is also a serious problem for educators who must decide what, if anything, should be done to improve the thinking skills of their students. They might benefit substantially from an overview of the burgeoning activity in the area of thinking skills, even if it is only a snapshot which freezes momentarily the evolution of a field very much in motion. It is the purpose of this report to provide such an overview.

The Task Force On Thinking was constructed to bring together individuals from a number of major fields in which research relevant to thinking skills is currently being done. Our purpose has been to pull together work from those various fields in search of areas where there is sufficient agreement and evidence to permit us to hazard some recommendations that might be useful to educators. We have also delineated important areas where we do not yet know enough to make such recommendations, and where additional research needs to be done.

The Need To Ask Some Hard Questions

While the purpose of this report is to pull together the work which has already been done in the area of thinking skills, we decided from the outset to address directly many of the tough questions which teachers in the trenches have asked about what some of them view as just another educational panacea.

Some of our approaches and conclusions, in virtually every section of the report, diverge substantially from the current conventional wisdom.

1. Defining the Problem. We have not attempted to add yet another full definition of the components of human thinking to the long list of existing taxonomies. Rather, we have attempted to winnow out of the complaints of educators, and out of the corrective instructional programs which they have developed, a more limited definition of those thinking skills which they have found to be both essential for successful academic work and missing in many of their students.

2. Possibility and Desirability. We have tried to avoid both the smug stance of deploring the failure of unnamed others to teach students thinking skills, and the facile assumption that the situation will change if we simply explain to them, one more time, the importance of those skills. If more than 2,000 years of consistent endorsement by most educational thinkers has failed to produce effective instruction in thinking skills, then something reasonably potent is in the way. We have, therefore, considered seriously the questions of whether thinking skills can be taught successfully enough to justify a serious commitment of effort and resources, and whether all students should be expected to develop these skills, at least as academics define them. Readers will also note that we move, in these two sections in particular, away from the relative safety of simply summarizing the views of others to making arguments for a particular point of view.

3. Recommendations. We have tried to offer recommendations which are realistic in light of the very real obstacles to teaching thinking skills which continue to exist. We offer these recommendations at three levels: a) for those who make educational policy; b) for those who construct or select instructional materials, and c) for classroom teachers.

The price of writing a report which addresses controversial questions directly, and seeks to do so without finding consensus in platitudes, has been

more than the usual amount of disagreement and debate. Not all Task Force members agree with all of what is said in this report. We were united, however, in our desire to say something of substance on an important topic, and in our resultant willingness to make some compromises as individuals in order to get that done as a group.

HOW TO READ THIS OVERVIEW

Because this report is an overview of a large and growing field, a great deal of information has been packed into it. We have, therefore, structured the report to make its contents accessible to readers with various levels of background in and commitment to the field.

1. A quick and relatively painless overview of the entire report is provided in the "Summary of Findings and Recommendations."

2. Readers of this summary who are interested in more information on particular findings and recommendations are referred, in that summary, to the appropriate sections of the report - each of which is, itself, introduced with an overview statement.

3. Readers who wish to go beyond this overview, and use it as a point of entry to the larger body of literature which it summarizes, will find that the "References" have been selected because they, themselves, provide readily digestable overviews of major subspecialities within the general field of thinking instruction.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

I. If the kinds of thinking skills necessary for academic success are to be developed, educational institutions, themselves, will have to undertake a major effort to develop them.

The kind of thinking emphasized in educational institutions is more abstract, critical,

systematic, and precise than that characteristic of most non-school environments. Because this difference is built into fundamental differences between the school and non-school environments, the resulting mismatch between the thinking skills which students bring to educational institutions and the skills they will need to do well there will persist until the schools undertake a concerted effort of their own to teach these "academic" thinking skills. (See "Defining the Problem," pp. 1-13.)

II. The demand that educational institutions teach thinking skills will increasingly come not only from those concerned with academic performance but also from those concerned with economic performance and effective citizenship.

While educators can expect little or no improvement in the thinking skills with which students enter school, they can expect rapidly growing demands from outside the educational system that students be proficient in those skills by the time they graduate. This is a result of the fact that major changes currently underway in American society are rendering the thinking skills which have always been essential to academic success increasingly essential to economic performance and effective citizenship as well. (See "Should Thinking Be Taught?," pp.14-23.)

III. Thinking skills can be taught, but the methods for teaching them must take full cognizance of the considerable difficulties inherent in that task.

The evidence that thinking skills can be taught is sufficient to justify a major effort to teach them. But there is also evidence that mastery of the abstract, critical, systematic and precise thinking, increasingly demanded outside as well as inside academic institutions, while ultimately rewarding, will be exceedingly difficult for many students. Unless the extent and nature of the effort to teach these skills reflects a full understanding of this difficult reality, the current wave of concern with thinking skills will pass with no more lasting effect than those which have preceded it. (See "Can Thinking Be Taught?," pp. 23-31.)

IV. Recommendations for Those Who Make Educational Policy (See pp. 31-34.)

A. Effective instruction in thinking skills will require a high priority, coordinated effort; piecemeal efforts will fail.

B. Effective instruction in thinking skills will require teachers who self consciously practice those skills and teach them by example, who are trained and rewarded for teaching them, and who are sufficiently current in their subject areas, and sufficiently confident of their own content mastery, to manage some of the more exploratory methods necessary to thinking-oriented instruction.

C. Instruction in thinking skills should extend across all grade levels; it should begin in elementary school and permeate education at all succeeding levels.

D. Instruction in thinking skills should extend across all subject areas; thinking skills should be taught primarily by changing the <u>way</u> in which all content materials are taught and not by isolated courses on thinking.

V. Recommendations for Those Who Construct or Select Instructional Materials (See pp. 34-37.)

A. Instructional programs which provide substantial amounts of work on "convergent" thinking (understanding the relationships among ideas) are preferable to programs which focus heavily or exclusively on "divergent" or "creative" thinking (generating large numbers of different ideas).

B. Holistic approaches, in which students practice the entire thinking process, are preferable to atomized approaches, in which they receive intensive practice on specific components of that process.

C. Holistic, thinking-oriented instruction in math and science should involve practice in discovering patterns, defining problems worthy of investigation, and collecting and evaluating data on those problems - in addition to the traditional drill on solving set problems.

D. Holistic, thinking-oriented instruction in the humanities and social sciences should similarly involve practice in defining questions worthy of investigation, the collection and evaluation of data on those questions, and the formulation and written presentation of the students' own viewpoints - in addition to the traditional practice of analyzing the viewpoints of others.

VI. Recommendations for Classroom Teachers (See pp. 37-47.)

A. Motivating students to undertake the demanding task of thinking abstractly, critically, and systematically will require not only pedagogy which permits such activity, but also instructional approaches and reward systems which require it, continuously.

B. Thinking-oriented instruction in the inductive areas of listening, observing, and reading, should require students to transform new information (e.g., by paraphrasing, summarizing, outlining, etc.), rather then simply committing it to memory in its original form, and should require students to relate that new information directly to their existing knowledge and preconceptions.

C. Thinking-oriented instruction in the area of creativity should be rooted in a secure knowledge base, rather than being taught in the abstract, and should require students to review systematically a variety of approaches to questions before settling on any one approach.

D. Thinking-oriented instruction in the deductive areas of constructing and evaluating hypotheses and arguments, and indeed in all of the above elements of the thinking process, should require students to develop, explain, and defend their points of view in open discussion with their teachers and each other, and, ultimately, to subject those views to the discipline of precise written expression.

I. DEFINING THE PROBLEM

OVERVIEW

There is, of course, no single best definition of anything. All subjects can be configured in a virtually unlimited number of ways. The best configuration depends upon one's purpose.

While we begin, below, with a general definition of the thinking process, our central purpose is to improve the thinking skills necessary for academic success. As a result, the specifics of our definition are derived from the skills which concerned educators have viewed as both essential to academic success and absent or poorly developed in many of their students; from the corrective instructional programs which those educators have established to deal with the problem; and, finally, from some attendant reflections on the kinds of thinking skills most strongly emphasized by academic institutions.

Such a review leads to the conclusion that the type of thinking which educators consider essential, and have found to be missing in many of their students, is different, in degree if not in kind, from the type of thinking characteristic of most non-school environments. The kind of thinking demanded in educational institutions tends to be more abstract, critical, systematic, and precise than its non-school counterparts. The following review of the major approaches to thinking instruction will make this distinction clear.

THE THINKING PROCESS IN GENERAL

We know relatively little for certain about the human thinking process. It can be, and has been, conceptualized in a variety of ways. But there is at least enough common ground among these various theories, and between them and the various approaches to thinking skills instruction, to provide a useful conceptual framework for discussing the thinking skills most important for academic success.

The breakdown of the thinking process into the components listed below was selected solely because: a) it is at least compatible with what we have learned about the thinking process; b) it provides a

useful set of "boxes" for sorting out the major current approaches to thinking skills instruction, and for understanding their relationships one to another; and c) it can be described using standard terminology which is readily recognizable by most classroom teachers and is readily translatable into the major classroom tasks which successful students must perform. No epistemological claims are made for this scheme beyond these three practical advantages.

As is the case with much of the work on thinking skills instruction, this is basically an input, process, output model. For the sake of clarity, and in order to enhance its usefulness as a classification device, we have artificially separated into four discrete steps what is doubtlessly a continuous and often non-sequential set of mental interactions.[1]

Induction

This is the process by which objects, experiences, and information are compared to stored information from previous experience, sorted and grouped under more general concepts, and placed into the memory. There seems to be general agreement that this is an active rather than a passive process - that we approach new experiences with existing "cognitive structures" or "schema" (intellectual cubbyholes) developed from past experience; that we interpret, sort and store new stimuli in terms of that existing structure; and that we use that structure to infer attributes and relationships which can not be discerned from direct observation. In this way, to the degree that we can, we "assimilate" new information into existing cognitive structures - a point to which we will return when we discuss some of the obstacles to teaching "academic" thinking skills.

Creativity

To the degree that new experience or information cannot be readily assimilated into existing cognitive structures, we must modify or "accommodate" the structure itself, to take account of that new information. There is very little agreement on how

we do this (trial and error among previously learned responses or more holistic reconfigurations of our way of looking at things); on why this process produces genuinely novel insights (the perception of new patterns and the definition of new problems not seen by others) for some "creative" people and not for others; or on how, if at all, instruction can help students to become more creative. But, the facts of individual human learning and collective human progress demonstrate our capacity for this kind of mental activity, and, as will be indicated below, it is viewed as a central academic skill to which much instructional effort has been devoted.

Deduction

This is the process by which we determine what follows logically from what we have learned inductively and constructed creatively. Deduction thus extends our understanding beyond what we have learned from direct sensory experience - into new areas and, in most fields of inquiry, back toward a testing against the world of sensory data.

Testing/Application

This is the process by which we try out our reconfigured view of the world, and the conclusions deduced from it, on the world of sensory experience - to see if it "works." The circle has thus been closed, and we have returned to induction.

PERCEIVED DEFICIENCIES AND INSTRUCTIONAL PROGRAMS

A review of the major programs which have grown out of concern about student deficiencies in thinking skills, and have offered instructional remedies for those deficiencies, reveals three things. a) Their models of the thinking process, to the degree that those are clear, are at least compatible with the general scheme just described, and with one another. b) While most programs deal to some degree with all the elements of the above process, almost all concentrate their efforts on one or two of those

elements. As a result, while sorting these instructional programs into the boxes just delineated leaves an occasional arm or leg sticking out, it works reasonably well. And, it should help to make clear the various types of programs currently on the market and their relationships to one another. c) An examination of the kinds of thinking skills these educators have found to be weak or missing in many of their students tells us a good deal about the particular kinds of thinking which are central to academic success and hence a good deal about the specific nature of the deficiencies which have produced the current wave of concern, among academics, with thinking skills. We review these programs here only for these three reasons, and not yet for the purpose of evaluating their relative merits.[2]

Piagetian Programs: A Focus On Induction And Abstract Thought

The model of the thinking process used by this group of instructional programs is usually built around a three stage learning cycle of "exploration," "invention," and "application" - which is very similar to the one just described. But, while they are concerned, to some degree, with all three of these steps, Piagetian programs are centrally concerned with induction.

Most of these programs emerged from concern among math and science teachers that many of their students seemed to have particular difficulties with the manipulation of abstract concepts - an essential skill in these areas of inquiry. Specifically, they found that students tended to memorize general principles, procedures, or formulas without understanding how they had been abstracted from a number of more concrete observations. And, because students did not understand their derivation, they could not reapply them to the solution of new problems - even if those problems differed only superficially from the problems that students could solve by rote recognition and response. Students with this difficulty were deprived, therefore, of the central advantage of abstraction or generalization - the ability to apply those generalizations to the solution of a wide variety of new but comparable problems.

Teachers confronted with this deficiency in their students found a name for it in Jean Piaget's distinction between two stages in the cognitive development of children - the stage of "concrete operations," in which children can reconfigure their immediate physical environment in their minds, but only with reference to physically observable objects, and the "formal operations" stage, in which they can also manipulate abstract concepts that have no immediate physical referent.

These educators concluded that their students were stuck in the "concrete" stage of development and built instructional programs to help them develop the capacity for "formal" thinking. These programs are also often referred to as "discovery" or "inquiry" learning programs, because they generally seek to develop the ability to construct and manipulate abstract concepts (and hence the ability to reapply those general concepts to new problems) by: a) beginning, not with general rules or formulas, but with a series of concrete examples or hands-on experiments, often drawn from the students' everyday experiences; and b) replacing lectures with questions and discussion which will help students to "discover" for themselves how general rules or formulas are inductively abstracted from those concrete experiments.

The contribution of this set of instructional programs to our current task of defining the nature of student deficiencies in thinking skills is two-fold. a) They highlight the fact that induction, the way in which we configure and store new information, may decisively affect our ability to make use of it. b) They make clear that abstract thinking is central to the thinking skills necessary to academic success - not for its own sake but because the ability to generalize from the concrete is necessary to students' ability to reapply those generalizations to new but related problems. The capacity for abstract thinking is, therefore, prized by academics because it is necessary if students are to move beyond memorizing and repeating what they are told toward independent thought.[3]

Problem Solving/Heuristics Programs: A Focus On Creativity And Constrained Critical Thought

Most of these programs use a four-step model of the thinking process which is not dissimilar from the

one delineated at the beginning of this section: a) understanding the problem; b) planning a solution; c) implementing the plan; and d) checking the results. Their central focus, however, is clearly on the first two steps in that sequence, and on the component of our model which we have labeled creativity.

These programs, like the Piagetian programs just described, grew initially out of math and science departments, though they have subsequently been extended to other curricular areas. Not surprisingly, students who could not apply to new problems the general rules created for them by others, also could not create new approaches to problems on their own. In particular, the educators who constructed these programs found in many of their students an impulsive appetite for closure which militated against looking at problems from a variety of perspectives and hence against generating new approaches and novel solutions.

To deal with that deficiency, they devised a series of mental exercises or "heuristics" to be tried in approaching a difficult problem - most of which are designed to create the opportunity for new ideas by delaying closure on a single approach and forcing, instead, the systematic consideration of a variety of approaches to the problem. The kind of thinking which these programs seek to develop is also referred to as "creative," "divergent," or "lateral" thinking - all indicating that the goal, at this stage in the thinking process, should not be to narrow down the range of approaches to problems, but to spin off as many different approaches as possible.

The contribution of this set of instructional programs to our current task of defining the nature of student deficiencies in thinking skills is that it makes clear the expectations of many academics that their good students should demonstrate not only an understanding of the knowledge generated by others but also an ability to generate new ideas and approaches of their own.

Thus, the thinking skills which are viewed as necessary for academic success include not only the capacity for abstract thinking but also the capacity for critical thinking - at least in the sense of being able to emancipate oneself sufficiently from standard approaches to a problem to devise new

approaches when the standard ones don't work. Because most problem solving instructional programs do not concern themselves with encouraging critical attitudes toward entire scientific paradigms or toward fundamental beliefs, values and social structures, as do the instructional programs in the next section, we have labeled the kind of thinking they seek to teach "constrained" critical thinking and have separated, somewhat artificially, what are in reality two ends of a single continuum.[4]

Critical Thinking Programs: A Focus On Deduction/ Testing And Unconstrained Critical Thought

With instructional programs in critical thinking, we move from programs based in math and science to those based in more verbally-oriented disciplines - in this case primarily in philosophy. We also move from programs which focus primarily on the first two steps of the thinking process, as delineated at the beginning of this section, to programs which focus on the last two steps. While some critical thinking programs include materials designed to help students construct arguments of their own, many focus on the evaluation of the arguments of <u>others</u>, in terms of their logical coherence and supporting evidence. As a result, these programs focus primarily on the <u>deduction</u> and <u>testing</u> components of the thinking process.

Instructional programs in critical thinking are a response to the long-standing perception of undue submissiveness on the part of many students with respect to the views of those whom they view as authoritative figures. This passive acceptance of the views of others limits their ability to function effectively as informed citizens, and even as critical readers.

The programs of instruction designed to deal with this deficiency focus on training students to strip down the arguments of others to their root assertions and then to examine those for logical fallacies and supporting evidence.

The contribution of this set of instructional programs to our definition of student deficiencies in thinking skills is that they make clear the expectation among many academics, particularly at the higher grade levels, that their students should think

independently - not only in the limited sense of generating novel approaches to set problems, but also in the sense of critically examining the viewpoints of others. And, that critical examination should take place even with respect to the viewpoints of individuals in authoritative positions, and even if their views are legitimized by reference to the basic beliefs, values, and social structures of the society in which the students were raised. This kind of critical thinking is not different in kind from that discussed in the preceding section. Both involve the ability to break out of existing paradigms. It is because of the breadth of the issues to which this form of critical thinking is to be applied that it has developed into a separate endeavor in the current literature on thinking. It is for that same reason that we have separated it here and labeled it "unconstrained" critical thought.[5]

Metacognition Programs: A Focus On Systematic Thought In All Portions Of The Thinking Process

Metacognition refers to consciously monitoring one's own thinking process in all of the stages of the thought process delineated at the beginning of this section. Concern with this area of thinking skills arose because of the discovery that many students' academic problems result from the fact that they are simply hasty or sloppy thinkers. As already noted in the section on the problem solving literature, which overlaps substantially with the literature on metacognition, students often seize on a particular approach to a problem without considering alternative approaches, begin to implement that approach without thinking through where it is likely to lead, readily tolerate gaps in their logic during that implementation, and frequently accept answers which a few seconds of common sense "eyeballing" ("estimation") would have proven wrong.

Programs of instruction centered on metacognition, like those which focus on the creativity element of problem solving, seek to provide students with a series of step-by-step procedures, designed to encourage systematic thinking about problems in a wide variety of content areas.

The contribution of these instructional programs to our current task of defining student deficiencies in thinking skills is that they make clear the value

which the academic world attaches to systematic thought and to the accuracy and completeness it produces. They also make clear the academic tendency to insist that impulsivity and even speed, if necessary, must be sacrificed to these goals.[6]

Writing Programs: A Focus On Precision In The Expression Of Thought

The perennial concern of teachers with student writing became a highly visible national concern with the dramatic increase in access to higher education which occurred in the post war period in general and in the 60's in particular. That concern about student writing became a concern about student thinking as expressed in written form, when research on writing moved from a focus on the written product to a focus on the writing process, and when that research, in turn, began to make use of the findings of linguists on the difference between oral and written cultures.

Those two bodies of research indicate that written communication, and the thought processes which produce it, must be more complex and precise than oral communication - primarily because written communication must be intelligible and persuasive to a diverse and personally unknown audience, without the help of the non-textual cues, opportunities for questions and answers, and the personal ties of affection or authority, from which interpersonal oral communication benefits.

Programs of instruction built around the writing process thus make it clear that the thinking skills necessary for academic success must include a precision in the communication of thought that goes beyond that afforded by the basic competence in oral expression which virtually all students possess.[7]

Cognitive Process Programs: A Focus On Specific Subskills

A final group of instructional programs can be described under the rubric of cognitive process instruction. While the general model of the thinking process implied by most of these programs is compatible with the four component model delineated at the beginning of this section, the defining characteristics of these programs are that they break

down those general components into a much larger number of smaller sub-components, use diagnostic testing to isolate areas of student weakness, and then provide intensive work in those areas.

While some of these programs are based on sophisticated theories of the thinking process, they focus on specific skills deficiencies in individual students, and hence shed little additional light on our current concern with defining the general nature of deficiencies in student thinking skills.[8]

SUMMARY DEFINITION OF ACADEMIC THINKING SKILLS

The purposes of the foregoing sections of this report have been: a) to specify in a general way what we mean when we talk about thinking and the thinking process; b) to do that in a way that will help to explain what the various instructional programs mean when they talk about teaching thinking skills; and, most important; c) to clarify what that large and growing number of educators mean, who insist that many of their students "can't think." This summary is devoted to that last question.

They obviously do not mean that students do not engage in the basic processes of induction, creativity, deduction, and testing. All physiologically unimpaired human beings do all of those things and would do them without benefit of any formal schooling whatever.

What they do mean is that many of their students do not do well the abstract, critical, systematic, and precise thinking central to the purposes of educational institutions at all levels. From this point on, we will use the terms "academic" and "non-academic" thinking as convenient shorthand expressions for highlighting the kinds of thinking that are more heavily emphasized in school than in non-school environments.

Both the importance attached by educators to that kind of thinking, and their belief that many of their students have difficulty with it, is clear from the foregoing review of the instructional programs designed to deal with those difficulties. We turn now to the question of why educational institutions place special emphasis on teaching students how to

engage in those kinds of thinking, consciously and on demand. That emphasis grows directly out of one of the central purposes of educational institutions. Those institutions serve not only to store and transmit existing knowledge, but also to create in the next generation of students the ability to generate new knowledge themselves. In the real world of educational practice this ideal is, of course, pursued very unevenly. But it is the importance many educators continue to attach to the ideal that accounts for the emphasis which they continue to place on abstract, critical, and systematic thought and on the precise communication of that thought.

Abstract Thought

Children, and even adults outside the formal school environment, learn primarily from a series of concrete personal experiences, interpreted or "mediated" by others with more experience, with repeated opportunities for questioning and correction. While some pedagogical approaches (e.g., "discovery" learning) may attempt to reinsert some of that personalized learning atmosphere into formal schooling, most educational institutions have little choice but to communicate knowledge at a much less personal and a much more abstract level, even when their goals are limited to transmitting to a new generation that which is already known. This is true because schools must summarize and transmit a great deal of information, distant from students' personal experiences, with a good deal less personal mediation than might be available in family or even apprenticeship relationships.

The knowledge which students must master in educational institutions is also likely to be more abstract than that which they learn outside the formal school environment, because the goal of most upper level education is to go beyond making students mere recipients of existing knowledge and moral precepts toward endowing them with the capacity to generate new knowledge and solutions to new problems on their own. And that capacity, as already indicated, requires mastery and manipulation of concepts abstract enough to make them useful for dealing with a wide variety of currently unforeseen problems.

Critical Thought

It is the same concern of educational institutions with creating the capacity for independent thought and the generation of new knowledge that also accounts for the high value many educators place on critical thinking. This is not to say that independent thought is always valued, even in the educational institutions. It is to say, that it is usually more highly valued there than in most non-school environments, as the concept of academic freedom for teachers and the number of instructional programs designed to generate it would seem to imply. Adaptation of knowledge to changing circumstances, and certainly the capacity to generate new knowledge, require a willingness to critically analyze traditional formulas and problem-solving approaches, and perhaps even basic societal beliefs and values.

Systematic Thought

The impulsive pursuit of quick closure so often cited and so often deplored as a characteristic of student thinking, may be perfectly functional in some non-school environments where quick reactions may be preferable to slow, meticulously careful ones. But, as those responsible not only for storing and transmitting but also for generating knowledge, academics have been afforded the luxury of living in a relatively protected and contemplative environment where they can take the time to "get it right." They tend to expect the same from their students.

Precision In Communication

The dominant mode of communication in pre-school and many non-school environments, and hence the form of communication with which students have had the most practice, is <u>oral</u>. As already noted, the <u>intelligibility</u> of oral communication is aided by the fact that speaker and listener often know each other, and can clarify their meaning by inflection, nonverbal cues, and questions and answers. Similarly, the <u>persuasiveness</u> of such communication may also be aided by interpersonal relationships of friendship or authority, and by the ability to quickly modify one's argument when confronted by signs of disagreement.

The dominant mode of communication in educational institutions, however, is written - taking information off of and putting it onto the printed page. Both the intelligibility and the persuasiveness of academic writing must be complete in the text itself - without any of the above aids from which oral communication benefits - to an unknown and diverse audience, trained to be skeptical. It is for these reasons that academic writing, and the thinking it reflects, require a higher level of complexity and precision than that for which oral communication has prepared most students.

"Academic" And "Non-Academic" Thinking

None of the above discussion of educational institutions is meant to imply that the thinking skills they require are different in kind from the thinking skills required in non-school environments. Human learning in any environment requires a substantial amount of abstraction from concrete experience, critique and modification of previous patterns of thought, systematic problem solving, and precision in communication. But there is certainly a substantial difference in degree, along all of those dimensions, between academic and non-academic thinking.

That difference may help to explain the striking and continuing disjunction between our repeatedly proclaimed commitment to teaching thinking skills and our apparent inability to do so effectively. If it is not thinking in general but "academic" thinking that we are trying to teach, then such thinking may not come automatically to our students once unnecessary obstacles to their natural inquisitiveness have been removed. And many of their teachers may not even be convinced that thinking skills, defined in this way, should or can be taught to most of their students.

We move now to a discussion of those latter two questions and then to their implications for educational policy, for curriculum, and for the classroom.

II. SHOULD THINKING BE TAUGHT?

OVERVIEW

Hardly anyone would disagree with the general statement that students should be taught to think. But once thinking has been defined more specifically as academic thinking, a legitimate question can be raised as to whether all students should be taught to think like academics, even if they could be. That is not a new or trivial question. It was, in fact, a negative answer to that question, among 5th century Athenians, which cost Socrates his life, and unspoken negative answers to this question, among contemporary educators, partially account for the fact that we have not taught thinking skills to our students more effectively.

We will argue that, whatever the appropriate answer to this question during earlier historical periods, current technological, economic, and political trends will make the "academic" mode of thought increasingly essential for the general population.

One of the dominant characteristics of the 21st century, for which we should now be preparing our students, is likely to be a continuing acceleration in both the amount of knowledge with which they will have to cope and the rate at which that knowledge changes and becomes obsolete. This will result from the interaction between an accelerating rate of scientific discovery and the growing power of media and computer technology to deliver and manipulate that information. Under those circumstances, retention of specialized and rapidly outdated information is likely to be less important to the life chances of our students than the capacity for continuous learning. And that capacity, in turn, will require the capacities for abstract and critical thought which we have already discussed. The capacity for abstract thought will be necessary to conceptually organize, sort through, and selectively use a growing and constantly moving lava flow of specialized information. The capacity for critical thought will be necessary to adapt to, and possibly even contribute to, continuous change not only in specialized content knowledge but also in whole

paradigms of thought. Thus, the thinking skills traditionally valued by educators because of that group's special responsibility for organizing, transmitting, and generating knowledge, may, in the information age, become practical necessities for most of their students as well.[9] It is against the backdrop of these broad societal changes that specific questions about the educational, political, and economic desirability of teaching thinking should be reviewed.

THE EDUCATIONAL ISSUE

Thinking and Content

There is some inevitable tension between straight content-oriented lecturing, at one extreme, and highly unstructured forms of thinking-oriented discovery learning, at the other. The advantage of lecturing is its efficient delivery of what is already known. Its disadvantage is that it provides students with no practice in thinking and hence in the skills necessary to discover or create knowledge on their own. The advantage of less structured, thinking-oriented pedagogies by which students are led to "discover" what is already known, is that they may in fact develop the thinking skills necessary for students to eventually generate knowledge on their own. Their disadvantage is that they take time, reduce the amount of content "covered," and run the risk of producing students who know how to learn but "don't know anything." Teachers who are responsible for a certain amount of "coverage" are often understandably reluctant to take the time that thinking-oriented instruction seems to imply.

While this is a widespread concern among teachers, and an understandable one for those who view the current concern with thinking skills as only the latest of a long series of educational panaceas, we believe that instruction can be carried out in ways that sharply limit any potential conflict between thinking and content coverage.

Specifically, thinking can be taught not as a separate subject matter, but by simply teaching traditional content materials in a different <u>way</u>. Indeed, there is a body of research which indicates that thinking processes are content specific and can be taught effectively only within the context of the

content area knowledge. There are also some research findings to support the proposition that combining content instruction with such thinking exercises as providing students with a conceptual framework in advance of reading textual materials, and requiring students to grapple with opposing viewpoints on the subjects under study, may actually increase the amount of detailed content material which they are able to remember.[10]

Finally, if some coverage of content material must be sacrificed to develop student thinking skills, that is a trade-off which we, increasingly, should be willing to make.

Thinking And Poorly Prepared Students

The capacities for abstract, critical, systematic and precise thought have always been recognized as characteristics which separate good students from mediocre ones, with the result that instruction in thinking skills is perhaps more prevalent in "Gifted and Talented" programs than anywhere else in the school curriculum. But there is a good deal of resistance to the idea that such "higher order" skills should also be central to instruction for more poorly prepared students who are still in need of drill in the "basic" skills of reading, writing and mathematics.

We agree that thinking skills, as we have defined them, <u>are</u> characteristic of most successful students. It is not surprising, therefore, that thinking skills instruction should be attractive to those primarily concerned with upgrading the quality of instruction and with doing more for "better" students.

We believe, however, that the development of thinking skills may also be one of the most efficient ways of helping poorly prepared students to measure up to rigorous academic standards and hence may be a key mechanism for reconciling the current concern with <u>quality</u> of education, and doing more for "better" students, with the earlier concern, born of the upheavals of the sixties, with maintaining broad <u>access</u> to education.

Thinking skills, in their most rudimentary form, can constitute important initial survival skills for

seriously disadvantaged students - by partially compensating for their deficiencies in more complex academic skills and thus buying them time until those skills can be developed through practice. In the verbal area, building vocabulary and reading speed, developing the conceptual apparatus necessary for ordering that information, and polishing the writing necessary to respond to it - all these are not "basic" but very complex skills, the development of which takes practice and time. But, if students can be taught, early, to strip down a body of information to its root assertions and related evidence, they can reduce the amount of reading material they must record and remember, until their reading speed improves. If they can be taught to grasp the central thrust of an argument, they can survive, and learn, until they develop the vocabulary and conceptual apparatus necessary to understand subtlety and nuance. And, if they can achieve at least clarity, by constructing their examination answers and papers around a few central ideas, logically elaborated and factually supported, most of their instructors will forgive them a lack of elegance until they have time to polish their writing skills. Such rudimentary thinking skills should never be accepted as long term replacements for the more complex skills necessary for genuine academic excellence, but they should be recognized as a necessary basis for those skills and hence as an appropriate early instructional emphasis for poorly prepared students.

Thinking: The Underlying Skill?

There is also the very interesting possibility that there may be a single substructure of thinking processes the improvement of which might simultaneously improve academic performance in quantitative as well as in verbal areas. The fact that some of the major instructional approaches to teaching thinking, such as the Piagetian and problem-solving approaches already discussed, began in the areas of math and science and are now being applied in verbal-oriented areas as well, is an encouraging indication that thinking skills may help to bridge the traditional verbal-math chasm. But in this, as in other areas to be noted below, more research needs to be done before any firm conclusions can be drawn.

THE CITIZENSHIP ISSUE

It is, once again, a truism to say that students, as citizens-in-the-making in a democratic society, should be taught to think independently. But, if the definition of thinking includes teaching students to critically analyze the views of authorities and even the basic beliefs, values, and social structures of their society (as implied both by many of the instructional programs in "critical thinking" and by our own concept of "unconstrained" critical thought) then that statement is no longer a truism. It becomes an important policy issue at both the political and school district levels.

Historically, many societies have nervously tolerated small clusters of intellectuals with such critical attitudes, in return for the new knowledge that they might generate. It is not clear, however, how many of those societies would have tolerated sending over one-third of their youth, as America does, off to institutions of higher education where they are taught to think as critically as their mentors. For that reason, individual teachers, particularly at precollege levels, might have legitimate practical as well as philosophical concerns about promoting in their classrooms much of what we have labeled "unconstrained critical thinking."

The proper balance between schools as agencies of socialization, which pass on to new generations the basic beliefs and values of the society, versus their role as havens where critical scrutiny of those beliefs and values is protected in pursuit of enlightenment and new knowledge, depends in part on large ethical issues about the nature of a good society which we will not address here. But, as a practical matter, we believe that the same knowledge explosion which has increased the importance of abstract and critical thinking skills for academic success will also increase their importance as a part of citizenship training.

Students of this generation will confront an acceleration in the rate at which new knowledge is generated, as well as revolutions in computer and media technology which will dump that information continuously in their laps. Unless they are taught the thinking skills necessary to manage this

explosion of new knowledge, and its tendency to increase the power of "experts," there will be a steady erosion of their confidence as citizens in their ability to understand and influence public policy. That level of public confidence, as measured in public opinion polls and voting levels, is already dangerously low.

Tempting as it may sometimes seem, we cannot respond to this problem by simply reaffirming for the public the traditional virtues of the American system in the traditional way, and leave it to technical experts and political leaders to deal with a more complex and imperfect reality. The postwar democratization of higher education has probably produced a citizenry too sophisticated and critical to accept such preachments. And, the flood of information produced by the media and computer revolutions has breached the information barriers which might have once permitted the maintenance of separate realities for policymakers and the public they serve. Finally, the growing economic integration and cultural interpenetration of the globe will impose a culturally diverse and morally ambiguous reality on our students whether we like it or not.

What may be needed, under these circumstances, is not simply a revival of citizenship education but its reformulation to give students an accurate picture of this complicated reality, which is both <u>intelligible</u> and <u>bearable</u> .

Rendering a complex and intractable world intelligible will require intellectually equipping our students for an ongoing process of collecting, summarizing, and selectively using those portions of the flood of new information which are most important to them and to their concerns as active citizens.

Rendering a complex and intractable world emotionally bearable, will require introducing them to the concept of the genuine dilemma - the frequent necessity in political life of choosing among equally legitimate but conflicting values and interests, when more of one good thing necessarily means less of another. More importantly, it will also require imbedding the American experience in sufficient historical and international perspective to permit the performance of the American system to be judged not only against what is <u>ideal</u> but also against what is apparently <u>possible</u> - in light of the historical

attempts of others to cope with similar problems and in light of the performance of other contemporary governments. Such a comparative perspective is not only fairer; it is also likely to be a good deal more favorable to the United States.

No amount of citizenship education will eliminate the disruption which accelerating technological and social change will cause. And, the education which we afford our students will be only one of many elements which will shape the relationships of the American people to their government. But citizenship education which provides students with the thinking tools necessary to understand the complexity of reality is certainly one contribution that we, as educators, might make to the possibility of keeping the democratic advantages of self-criticism and reform while still maintaining public appreciation of what is good about the American system.

THE ECONOMIC ISSUE

The relationship between thinking skills and economic success is a critical issue, but one on which we are much less sure of our ground. The spate of recent national reports on both pre-college and college-level education, the presence on the committees which wrote those reports of political and business leaders as well as educators, the rise of education to a position of some prominence as a political issue - all indicate that America has rediscovered, in a time of growing international competition and economic adversity, what she may have forgotten during the postwar economic boom. The performance of the educational system is critical both to the overall performance of the economy and to the life chances of individual graduates within it.

But, the long-term direction of the American economy and the implications of that direction for education are not at all clear. They are subjects worthy of a good deal more attention than they have yet received from both the academic and non-academic sides of the fence.

Accordingly, we hazard, below, only an argument on the importance of building a work force trained in thinking skills. With respect to the contribution of

thinking skills to the life chances of individuals within that economy, we rest content with posing the question.

The Economy

The global debate over the relative merits of planned and free market economies is still very much under way. But it is increasingly clear that the strong suit of free market economies (in their competitive sectors) is their decentralized decision making and their resultant ability to make effectively the multitude of decisions which, collectively, allocate and reallocate resources and people to their most efficient use. As the rate of technological change accelerates, one of the major challenges to the educational system will be to train a work force creative and flexible enough to lead, or at least to adapt to, that accelerating rate of change.

If much of the current talk about "technical literacy" and "high tech education" leads only to the growth of more and more highly specialized technical education, we will do our students a disservice and contribute to the continuing decline of America's economic position internationally. If "high tech" means anything, it means <u>change</u>. We have already argued, at the beginning of this section, that specialized educational content, particularly in technical fields, will quickly become obsolete. And, once new products are ready for mass production, even in "high tech" industries, many of the production jobs will migrate to less developed countries where labor and resources are cheaper - a process already clearly under way.

There is a growing and persuasive body of economic thought which argues that the economic prosperity of the industrial states, with their higher levels of education and labor costs, will increasingly depend on their capacity to develop and <u>initially</u> exploit an endless series of new opportunities and products.[11] The ability to do that will depend, in part, on an educational system which produces a professional work force with the general thinking skills necessary to continuous learning.

The Individual In The Economy

There is some consensus among economists that the emergence of strong foreign competition in the production of industrial goods has introduced a period of slower growth for the American economy, and that the economy is being restructured internally away from heavy industry and toward service and, less certainly, "high tech" industries.

One school of thought holds that these two changes can result in sufficient economic prosperity to maintain genuine opportunities for most of our able and industrious graduates, with the best opportunities being available for those possessed of the thinking skills necessary to continuous learning and to the resultant ability to adapt to a rapidly shifting job market.

Another school of thought, however, holds that even a prosperous economy based on service and "high tech" industries will tend to produce limited numbers of responsible and well paid positions and a very large number of menial and poorly paid positions.[12]

This is another area in which more research and more communication between the academic and business worlds will be necessary before any firm conclusions can be drawn. Whatever the ultimate resolution of this issue, however, it seems highly unlikely that American educators would ever be called upon to educate a permanent "underclass" to be content with that status. While the statistical chances for individual students to find rewarding employment will vary over time, it will remain the continuing responsibility of educators to prepare all of their students in such a way as to maximize their opportunities. And, in an economy dominated by an accelerating rate of change, thinking skills, and the resultant capacity for continuous learning, seem likely to grow in importance.

ACADEMIC THINKING AS A PRACTICAL NECESSITY

Abstract, critical, and systematic thinking, and the precise communication of thought, have always been necessary for educators because of their responsibility for storing, transmitting, and, in particular, generating knowledge. Understandably, they have always prized that kind of thinking in their students.

It is the central thrust of the foregoing section to argue that, in the political and economic age now aborning, this kind of thinking will increasingly become a practical necessity for the general population and hence for all of our students - in their lives as well as in their studies.

III. CAN THINKING BE TAUGHT?

OVERVIEW

Even if we could achieve agreement that thinking, as we have defined it, should be taught, can we teach it to most students with an acceptable expenditure of effort and resources?

Had we not focused on the more demanding modes of thinking required in academic institutions, the response to this question would certainly have been that no formal instruction is required for people to think, or that all instruction already serves this purpose. The definition we have proposed, however, creates the opposite problem. It raises questions of whether the kind of thinking we are addressing is not built into, or left out of, the genetic "hard wiring,"- questions of whether it is subject to instruction at all.

Such data as exists on institutional programs is generally positive - albeit somewhat weakened by the fact that the evaluations of those programs are understandably tied tightly to their specific educational goals, and hence tell us little about whether gains in those specific areas transfer to improvement in general academic performance.

We will argue here that thinking can be taught, but not easily. Success will probably require a major and coordinated effort. If it were easy, after all, we'd have done it long ago. As we argued in the opening section on definition, academic thinking is different, at least in degree, from most non-academic thinking, and our students do not arrive well prepared to do it. Those who expect to teach thinking skills should also expect to start early, keep at it continuously, and encounter some resistance.

The difficulties involved in teaching students to think abstractly, critically, and creatively will serve to illustrate some of the problems, and to lay the groundwork for recommendations tailored to take full cognizance of those problems.

CAN ABSTRACT THINKING BE TAUGHT?

The Issue of Intelligence

Abstract thinking is often associated with native intelligence, in part because the questions on "IQ" and aptitude tests must be abstract if the test makers are to sustain their claim that they are measuring general abilities (and not acquired knowledge), and hence can predict general performance in a wide variety of knowledge domains. And, intelligence has been popularly assumed to be genetically determined and largely impervious to instruction. Some support for this position has resulted from major instructional efforts designed to raise intelligence test scores, which have produced only mixed results.[13]

Recent research on intelligence, however, is moving toward the conclusion that intelligence may not be a unified capacity, but rather a diverse set of abilities held together only by the fact that performance on test items which measure those diverse abilities are reported by test makers as a single aggregate score. And there is some evidence that performance on many of those test items may be related as much to learned strategies or techniques as to genetically determined ability.[14]

The Issue of Transfer

Another source of concern about the ability of instructional programs to improve the capacity for abstract thinking has emerged from findings that improved test scores achieved as a result of training in some general cognitive operations have often not "transferred." Specifically, they have often failed to improve: a) performance on test questions which were similar but not identical to the ones on which direct instruction was provided, b) performance on similar thinking tasks in other content domains, or

c) general levels of academic performance. This has led to fear that instruction in general thinking skills may not have much impact on general academic performance whatever the gains on test items tightly tailored to the instruction itself.[15]

This failure of transfer, however, can be explained more optimistically and, perhaps more plausibly, by emerging evidence that the effective use of many thinking skills requires substantial domain-specific knowledge and that the improvement of general academic performance as a result of thinking instruction will require instruction in the holistic combination of a number of cognitive processes characteristic of most actual academic work. If these two propositions prove to be accurate, the problems with the transfer of thinking skills could be overcome by simply teaching those skills more holistically and in the various content domains.[16]

General Grounds for Optimism

Research in linguistics provides an additional general argument for optimism about our ability to improve thinking skills. The fact that all physiologically unimpaired humans can master the enormously complex business of learning a language, in a short period of time and under learning conditions which are usually far from optimal, strongly suggests that whatever genetic differences exist among individuals may be small in comparison to the enormous potential of the average mind. Hence, even if upper limits of thinking ability and academic performance are imposed by genetic limitations, there is no reason to believe that the average individual's ability to think could not be significantly improved by instruction, within those broad genetic limitations, in much the same way that training and practice can almost always improve athletic performance in spite of absolute upper limits imposed by genetic heritage.[17]

CAN CRITICAL THINKING BE TAUGHT?

In the first section of the paper, we distinguished between instructional programs that

sought to develop students' abilities to look at set problems with established parameters from a variety of viewpoints, on the one hand, and programs which hoped to develop the ability and inclination to question even those parameters, on the other. We labeled the first set of abilities "constrained" critical thinking and the second "unconstrained" critical thinking. Neither type of program seeks to "wipe students' minds clean" of all existing preconceptions. Rather, both seek to build the ability and inclination to consider a variety of viewpoints on any subject and modify one's own views when warranted. We believe that instruction can improve the capacity for both kinds of critical thinking, but that neither form of instruction will be easy.

Constrained Critical Thinking

Instructional programs in problem solving have demonstrated significant improvement in getting students to delay closure around a single familiar approach to problems and in getting them to view problems from a number of perspectives. We believe that such problem solving techniques can be successfully taught.

But the degree to which that emancipation from impulsivity will transfer over time and to other content areas is less clear. And, the fact that such instructional training is necessary to get students to do such a transparently sensible thing as looking at difficult problems from a variety of perspectives raises the possibility that the perpetually open-minded stance we would like to encourage in our students is more difficult and, in some sense, more "unnatural," than we as trained academics might at first imagine.

Some findings from cognitive psychology point in this direction. First, as indicated in our earlier discussion of induction, humans apparently do not approach new experiences in an entirely open-minded way. Rather, to the degree that we can, we seek to impose order on otherwise chaotic sensory stimuli by sorting and interpreting them in terms of "cognitive structures" or "schema" constructed from past experience. We apparently change those schema only grudgingly and only when an accumulation of new information, which cannot be interpreted in terms of them, requires such a change.

The tenacity of these schema is indicated by additional research findings. Most of the mistakes made on controlled tests of inductive and deductive reasoning result not from the inability to determine which answer the rules of inference dictate as the correct one but from the unwillingness to abandon preconceptions, even when logic conflicts with them.[18] Indeed, studies of even expert problem solvers, those who are presumably the best at the task of looking at problems in new and varied ways, have revealed that one of their initial techniques is to try to transform the problem into one which is similar to a problem they already know how to solve.[19]

The crucial point to be made here is that the obstacles created by such schema to open-mindedness are <u>not</u> the result of defective thinking or of faulty previous education. They are reflections of the existence of mental processes which are absolutely necessary for making sense out of our world. But they do impair to some degree our intellectual freedom of movement when confronted with new and difficult problems, and hence conflict to some degree with the kind of critical thinking which is ideal for certain academic tasks.

This is not to say that this kind of critical thinking cannot be taught. There is good evidence that it can be. It is only to say that instruction is likely to be most effective if it is shaped by the recognition that this element of academic thinking has been and will be difficult to teach and sustain precisely because it conflicts, to some degree, with thinking processes and habits which are highly functional in some non-academic realms.

Unconstrained Critical Thinking

We are optimistic with respect to even this most demanding end of the critical thinking continuum. Education clearly can and does impact on the basic beliefs and values that students bring from their non-school backgrounds. Any teacher who has had the opportunity to observe changes in the basic outlook of students as their education progresses has accumulated a good deal of impressionistic evidence to that effect. And, longitudinal studies of attitude change among college students, for example, have produced evidence to support those impressions.[20]

But, here too, effective instruction will require recognition that the task will not be an easy one. We have already dealt with the external philosophical and political objections which might be raised to teaching students to critically analyze the arguments of highly placed others or even the basic beliefs and values of the society into which they were born. We focus here on obstacles to that kind of thinking which may exist within students' own mental and emotional makeup.

There is substantial evidence from history and from social psychology to indicate that most humans find it extremely difficult to maintain a more or less permanently open-minded stance toward authorities and the basic beliefs and values they preach - a stance which some instructional programs in critical thinking seek to develop, and which many academics view as both their prerogative and their jou. Two large and diverse bodies of such evidence merit mention.

It is worth remembering, as we set out to make critical, open-minded thinkers of our students, that the historical record of humankind for maintaining that kind of stance, at least at the level of the general population, is a very mixed one. For example, the commitment to science as a way of knowing and to materialism as a way of valuing, which had become the dominant modes of thought in industrialized Europe by the 19th century, and which swept through the rest of the world along with European colonialism in the early 20th century, have much in common with the open-minded mode of thought implied by the term "critical thinking." Science, in the last analysis, believes in the reality of only physically observable things, or things that have physically observable effects, and constantly revises our view of reality in light of new evidence. As a result, it is perpetually distrustful of all absolutes and certainties - whether they are grounded in religion or in yesterday's scientific orthodoxy. Materialism, as a way of measuring human success and worth, is equally opposed to all claims of lifelong and automatic status or worth - whether they are based on bloodlines or on yesterday's economic successes.

If there is a common theme which ties together the classic analyses of the transformation of Europe

under the impact of these ideas in the 18th and 19th centuries with the voluminous literature on the "modernization" of the non-Western world in the 20th, it is the havoc which this increased level of uncertainty initially wreaked at both the individual and societal levels. Subsequent studies of the mass movements spawned by that transformation indicated that much of their appeal lay precisely in the sense of certainty provided by their comprehensive and closed-minded ideologies. This discovery, in turn, led a whole generation of scholars to raise serious questions about the amount of intellectual freedom that the average individual is able to tolerate.[21]

A second and closely related block of evidence, which indicates the difficulty of sustaining an open-minded view of the world, is derived from the way in which most people react to more sudden breakdowns in the beliefs and values which they use to make sense of their world. Studies of a wide variety of such situations by social psychologists, from passing crises to large scale social collapse and revolution, indicates the tendency to respond to the resulting uncertainty not with celebrations of intellectual emancipation but with great anxiety, and with a rush to affiliate with very simplistic, closed-minded and intolerant ideologies, religious cults, doctrines, etc..[22]

None of the foregoing should be interpreted as an argument that what we have called unconstrained critical thinking cannot or should not be taught. Indeed, the ability and inclination to engage in discussion of opposing viewpoints even in the realm of basic beliefs and values is one of the hallmarks of an educated person. It *is* to say, as already noted in the section on constrained critical thinking, that a certain amount of structure and closed-mindedness is apparently necessary to the way humans relate to their environment, that prying open and holding open the mind will be as difficult as it is noble and necessary, and that our approaches to teaching thinking should take realistic cognizance of that fact.

CAN CREATIVITY BE TAUGHT?

In our earlier discussion of problem solving, we touched upon instructional programs designed to hold open the mind to new approaches and hence increase the chances that genuinely creative ideas might emerge. This section deals with the question of whether we can teach students how to actually generate creative ideas - usually defined as ideas that are both genuinely novel and important. In spite of the existence of a number of programs and books which claim to teach creativity in this sense, we find the supporting evidence weak, to date, in two regards.

First, the attempt to find characteristics or capacities which are subject to instruction and might be causally related to creativity has been disappointing. Traditional measures of intelligence, ideational fluency (the ability to generate large numbers of ideas) and others do not show strong correlations with actual creative output. And, while some significant correlations have been found between creativity and certain attitudes (e.g. open-mindedness and receptivity to new ideas), those correlations might very well result from the fact that such attitudes are not analytically distinct from creativity itself.

Secondly, the measurable impact of instructional programs designed to increase creativity directly has been unimpressive.[23]

The only note of optimism lies in the fact that studies of how demonstrably creative people work indicate that creativity requires not only the mysterious ability to generate creative ideas, but also its interaction with more convergent methods for screening, and learning from, those ideas - which methods may be subject to instruction. This finding may indicate that effective convergent thinking is a necessary but not sufficient condition for producing creativity.[24] If so, perhaps we should devote our efforts to teaching the more convergent aspects of thinking to which the bulk of this paper is devoted, and hope that they create the preconditions for the "light bulb" to go on.

ACADEMIC THINKING AS AN "UNNATURAL" ACT

We argued in the previous section that thinking skills, as educators define them, will increasingly become a practical necessity for the general population and that it is therefore our responsibility as educators to try to endow all of our students with these skills.

In this section we have argued that it's not going to be easy to do that. As already noted, garden variety human beings clearly abstract general rules from concrete experience, and modify their previous views, on a daily basis. But, the manipulation of highly abstract concepts as a steady diet, and the adoption of open-mindedness as a more or less permanent stance - these are clearly something of a strain.

The human foot was not built for ballet dancing. With training, it can endure the strain and create beauty. Perhaps the human mind was not built, or at least not initially trained, for a steady diet of academic thinking. With training, it can, however, endure the strain and create knowledge.

This interpretation of the possibility of teaching students to think has the advantages of being congruent both with what we know about how the human mind works and with the unfortunately limited success we've experienced in teaching thinking to date. It also has clear implications for the ways in which we might go about teaching thinking in the future. We turn now to recommendations on that subject.

IV. RECOMMENDATIONS FOR THOSE WHO MAKE EDUCATIONAL POLICY

The recommendations in this and the following sections flow directly from the theoretical analysis in the previous three sections. As a result, the justification for each recommendation will be confined to a list of brief supporting arguments derived from the more elaborate preceding analysis.

A. Effective instruction in thinking will require a high priority, coordinated effort; piecemeal approaches will fail.

Altering the structure of individual content courses in such a way as to emphasize thinking skills is likely to improve even straight content mastery, and such alterations in individual courses should, of course, be encouraged. But, given the difficulty of teaching thinking skills, anything less than a coordinated institution or district-wide effort is unlikely to produce significant and lasting results. This is an area in which half measures are likely to be a waste of time and effort. The three following recommendations are more specific derivations of this general one.

B. Effective instruction in thinking skills will require teachers who self consciously practice those skills and teach them by example, who are trained and rewarded for teaching them, and who are sufficiently current in their subject matter, and sufficiently confident of their own content mastery, to manage some of the more exploratory teaching methods necessary to thinking-oriented instruction.

The idea that learning to think in productive ways about content materials is more important than simply committing large amounts of those materials to memory has been around for a long time. Most teachers are familiar with this idea and would endorse it in the abstract. We have already discussed above some of the reasons why so little has been done to implement this widely shared view. Three reasons pertain directly to teachers and to teacher training. First, abstract, critical, and systematic thinking can be demanding and anxiety producing for teachers as well as for students, particularly inasmuch as they are themselves often the products of educational institutions which have not focused on developing thinking skills. Secondly, thinking-oriented instruction is usually much more labor intensive than simply using the pre-packaged materials provided by textbook publishers, conflicts with the demand for "coverage" in curricula which tends to grow endlessly by accretion, and is unlikely to be undertaken by hard-pressed teachers unless the reward system somehow recognizes that increased level of effort. Finally, teachers, many of whom may be assigned to teach in areas in which they have had little initial or on-going training,

will be understandably reluctant to go beyond memorization of text materials and formulas into the less controlled techniques necessary to teach students to think independently and critically - until their own standing as up-to-date authorities on the subject matter is secure and clearly visible to the students. As a result, even those teachers who are committed to the importance of thinking skills are unlikely to revamp their classroom instruction accordingly, unless teacher training and professional development programs are undertaken which will remove at least these three primary obstacles.

C. Effective instruction in thinking should extend across grade levels; it should begin in elementary school and permeate education at all succeeding grade levels.

1. The physiological obstacles to an early emphasis on thinking skills, once thought to be posed by Piaget's stages of cognitive development, have been called into question by subsequent research that indicates that cognitive development may depend less on age and more on knowledge level than Piaget thought.[25]

2. The power of existing ways of thinking to help or hinder thinking, and the increasing difficulty in changing them if they are constantly reinforced as students grow older, makes it important to shape those ways of thinking as early as possible.

3. As is the case with all other academic skills, thinking skills will develop and be retained only if they are supported by continuing reinforcement.

D. Instruction in thinking skills should extend across all subject areas; thinking skills should be taught primarily by changing the <u>way</u> in which content is taught and not by isolated courses on thinking.

While a case can be made for special, intensive thinking instruction for very poorly prepared students, teaching thinking "across the curriculum" has a number of major advantages.

1. It will produce better content mastery. Thinking-oriented exercises which require students to actually "process" new information, i.e., build or modify cognitive structures to deal with that information, will improve content mastery, even as measured by the traditional standard of simple factual recall.

2. It will circumvent the problem of transfer. There is a growing body of evidence that effective thinking requires a substantial knowledge base and that thinking skills learned separately may not transfer to work across knowledge domains.

3. Like thinking instruction across grade levels, instruction across content areas will provide the continuing reinforcement necessary to building and sustaining improvements in thinking skills.

4. It will increase the chances that teachers will actually be willing to modify their teaching in order to emphasize thinking. Both administrators and teachers will be more likely to undertake thinking-oriented instruction if they can do so by changing the <u>way</u> they teach existing content courses rather than if room has to be made for new thinking courses, or even new modules within courses.

V. RECOMMENDATIONS FOR THOSE WHO SELECT OR CONSTRUCT CURRICULAR MATERIALS

It is very difficult to evaluate the effectiveness of <u>individual</u> instructional programs in thinking because of the need for, and the difficulty in securing, longitudinal data, and because of the difficulty of holding constant the potentially decisive impact of the individual instructor. It is virtually impossible to <u>compare</u> the effectiveness of different programs and pedagogical approaches, because of the absence of agreement on goals and hence on performance measures. As a result, we have limited our recommendations here to those which flow from the general research literature on thinking.

To the degree that there is a central theme to the following recommendations, it is that much of

what currently passes for thinking skills instruction is too fragmented to be fully effective. In an attempt to get on the thinking skills bandwagon, test makers, text publishers, and many school districts have committed themselves to assessing and teaching long lists of thinking skills - with very little clarity on how each of those skills relates to the other, to any overall concept of the thinking process, or to the improvement of students' general academic performance.[26]

A. Instructional programs which provide substantial amounts of work on "convergent" thinking (understanding the relationships among ideas) are preferable to programs which focus heavily or exclusively on "divergent" or "creative" thinking (generating large numbers of different ideas).

1. Evidence bearing on the effectiveness of creativity-centered programs is mixed and generally weaker than evidence for the effectiveness of programs which focus on more convergent skills.

2. Most average students have a more immediate need for the convergent thinking skills necessary for academic survival than for training in creativity.

3. There is some research support for the proposition that developing convergent skills may be a necessary precondition for the development of creativity.

B. Holistic approaches in which students practice the entire thinking process are preferable to atomized approaches in which they receive intensive practice on specific subskills.

The cognitive process approach - which breaks thinking down into relatively small component parts, attempts to identify specific areas of student weakness, and provides specific corrective instruction - makes sense primarily for students with serious skills deficiencies. For most students, a holistic approach, or at least the integration of drill on more specific subskills into a coherent holistic framework, is preferable for the following reasons.

1. Almost all academic tasks require the combination of a number of specific cognitive processes, and students may need help precisely with the task of making those combinations. Put another way, practice on holistic thinking skills provides some assurance of practice on the underlying subskills, while the reverse is not necessarily true.

2. Perhaps for this reason, measurable improvement in the performance of specific subskills often does not transfer to improvement in general academic performance.

3. Significant improvement in thinking skills may require more repetition than the attempt to cover a large number of specific subskills will permit on each one of them.

4. The relevance of work on more complex thinking operations, which are closer to the demands of regular academic and job-related work, may be clearer to students and hence may benefit from a higher level of motivation.

C. Holistic thinking-oriented instruction in math and science should involve practice in discovering patterns, defining resultant problems worthy of investigation, and collecting and evaluating data relevant to those problems - in addition to providing practice in solving set problems.

Many of the exercises in problem-solving books, like much of the content instruction in math and science, ask students to respond to problems already identified as important, with all of the relevant data specified in the problem. What is left for students to do is to apply a rehearsed series of steps necessary to find the solution. Because the solution is deductively derived, factual testing is also unnecessary. While this kind of work is important to improving student performance on similar problems in other academic and nonacademic work, it truncates the thinking process at both ends. As a result, it runs the risks of denying students practice in seeing patterns and identifying important questions on their own, at one end of the process, and in empirically checking the reasonableness of their solutions, at the other. Adding to the problem-solving approach the Piagetian emphasis on induction

and, to a lesser degree, on application/testing, will help to assure practice in combining all of the elements of the thinking process.

D. Holistic, thinking-oriented instruction in the humanities and social sciences should involve practice in defining questions worthy of investigation, the collection and evaluation of data on those questions, and the construction and written presentation of students' own viewpoints - in addition to analyzing the viewpoints of others.

Some approaches to teaching critical thinking focus heavily on analyzing the arguments of <u>others</u>. To the degree that they do, they truncate the thinking process in the verbal areas in the same way that rote problem-solving approaches do in math and science. The discovery of questions worth investigating, as well as the initial accumulation of evidence and the formulation of a point of view, have already been done for the student. Students are asked only to subject that existing argument to the tests of deductive logic and supporting evidence. Combining such approaches to critical thinking with process-oriented writing programs, in which students must form and support their own points of view, will help to assure practice in combining all of the components of the thinking process.

VI. RECOMMENDATIONS FOR CLASSROOM TEACHERS

Teachers will not find here materials for tomorrow's lessons. Rather, our purpose in this as in preceding sections of the report is <u>aggregation</u>. As a result, we have not attempted to prescribe any particular set of specific classroom techniques for teaching thinking. Rather, we have listed the <u>kinds</u> of existing techniques which seem compatible with the theoretical analysis in the rest of the report, and have then listed a few specific illustrations for each. Our hope is that this approach will provide classroom instructors with a general set of guidelines for reconsidering their own repertoires of teaching techniques, and for sorting through the rapidly growing number of thinking-oriented texts and workbooks now coming on the market.

There is, however, a common theme - derived from the foregoing theoretical analysis - which is reflected in the immediately preceding recommendations

on general policy and curricular approaches, and which ties together all of this concluding section. It is that teaching thinking skills, while possible, will not be easy.

As argued above: a) academic thinking is different in degree, if not in kind, from most of the thinking that is practiced in the non-school environments from which our students come; b) academic thinking conflicts to some degree with the habit of rapid closure around existing cognitive structures that is often functional in non-school environments; and c) certain elements of academic thinking can, as a result, generate both personal anxiety and negative social pressures.

As a result, we focus in this section both on teaching approaches which permit students to engage in academic thinking, and on those which require that kind of thinking.

We have grouped teaching techniques, of both types, under the same general classification scheme used at the beginning of this report. We have begun each of the resulting four sections with a statement of "general principles" which are derived from the theoretical analysis in the body of the report and which provide the theoretical underpinning for the teaching approaches which follow them.

THE MOTIVATION TO THINK

General Principles

The decision to include this preliminary section grows out of our belief, grounded both in the foregoing theoretical analysis and in practical classroom experience, that thinking, as we have defined it, will initially be a difficult and anxiety-producing activity for many students. Generating the motivation and self-confidence necessary for students to make the attempt is, therefore, an important prerequisite for success, as indeed it is for most teaching activities.

What follows is a sampling of some of the techniques which are compatible with this general conclusion.

Techniques Which Permit Thinking

Many students start with the assumption that there is a single "right answer," which it is the job of teachers and other authority figures to provide, and which they themselves are incapable of providing. Some techniques for overcoming that tendency and getting students to accept the legitimacy of multiple frames of reference and, more generally, the possibility of thinking for themselves, include the following.

1. Downplay the infallibility of the "authorities" with whom students feel they must be compared by: making it clear that even authorities must formulate their positions on the basis of perpetually incomplete information, pointing out that authorities often disagree with one another, noting that current authorities frequently turn out to have been wrong as our knowledge grows, etc..

2. Downplay your own infallibility as the chief authority figure with whom students must deal by:

- Demonstrating for them the process which eventuates in the impeccable products you deliver in class.

- Letting students see multiple drafts of your own written arguments or math work with the revisions showing.

- Making clear that learning is a continuous process, by giving some credit for students who can specify in a written paper the remaining areas of uncertainty, and the kinds of evidence which would be necessary to resolve that uncertainty, or explain why they are "stuck" on a math or science problem.

3. Gradually build up the confidence of students by teasing out of them, and helping them to develop, the ideas they do have. The key to this technique is to start in areas of their strength, so that students can win a few in the early going, and then ease them into more difficult tasks. Specifically, this might be accomplished by:

- Moving from "concrete" to more "abstract" exercises, and then back again (in the Piagetian sense described above); e.g., from questions about students' personal experiences and feelings, to more general but still contemporary questions which apply to groups of people who are familiar to but extend beyond the individual student, to more eternal philosophical questions about the human condition, and then back to the concrete by spelling out the implications of these broader questions for students' personal concerns.

- Moving from less threatening to more threatening assignments, e.g., writing assignments in which students write first for themselves, then for peers, then for the teacher who helps only to shape the writing, and only finally for a grade.

- Reducing the fear of grade failure and encouraging risk taking by: not grading early work, grading everything so that no single grade affects the final grade very much, weighting early grades lightly and later grades more heavily, and generally using grades to appraise students of their current level of achievement without numerically precluding the possibility of salvation later.

4. An alternative way to build up student confidence (albeit a risky one) is by making very heavy demands on students, thus forcing them to prove early that they are smarter than they thought they were. This is, of course, the equivalent of teaching someone to swim by throwing him/her in, and is the opposite of the previous approach. The risk of pushing students into despair or rebellion with such an approach might be reduced by:

- Making equally heavy and visible demands on yourself as a teacher in providing students with assistance - so that they can see that your demands reflect caring and not hostility.

- Repeatedly telling students that the standards are very tough and that some early failures are to be expected.

- Weighting the early grades lightly to reduce the overall impact of those early failures on the final grade.

Techniques Which Require Thinking

While the techniques just listed are all designed to increase students' self-confidence in such a way as to allow them to think on their own, the following techniques are designed to require them to think independently by refusing to provide answers for them.

1. This is, of course, the central characteristic of the "Socratic" method, in which questioning and guided discussion leads students to discover truths for themselves. The merits of this approach are detailed in a later section, but it belongs here as well. The two approaches which follow immediately are only contemporary adaptations of this classical pedagogy.

2. "Discovery" learning in the sciences and "exploration" learning in some non-scientific areas both refuse to provide students with answers (general principles, laws, formulas, etc.), provide them instead with a series of hands-on exercises, and ask them to derive the appropriate general principles for themselves.

3. A more structured, "top down" approach involves building the presentation of any subject around opposing points of view on that subject (available, in reality, at the cutting edges of many scientific disciplines, and generally available outside the sciences), presenting each point of view as an advocate would present it, refusing to tell students your own point of view until they have completed their assignment, and building those assignments around the evaluation of those opposing views and around the construction and defense of viewpoints of their own. There are several advantages to this technique.

- It denies students the easy out of simply accepting the opinion of an authority and forces them instead to develop and defend ideas of their own.

- It opens the way for discussion of questions of logic and evidence according to which the various points of view must be evaluated.

- It provides students with a realistic picture of how knowledge and policy actually develop in a world in which there is, in reality, no single "right" answer.

- It is a nice compromise between purely lecture and purely discovery methods of teaching, because it provides the teacher with an opportunity both to deliver existing information, interpreted from a variety of viewpoints, and to generate structured discussion which requires students to think, in assessing the relative merits of those viewpoints.

- The element of controversy may help to develop the excitement and engagement, without which learning seldom happens.

INDUCTION: LISTENING, READING, OBSERVING

General Principles

1. The ways in which students conceptualize a topic or problem, and hence the ways in which they order and mentally store information about it, are often critical to their ability to use that information for problem solving and even to their capacity for simple factual recall.

2. Both factual recall and problem solving will be improved if students actively "transform" rather than passively accept new information, and if they consciously relate it to their existing knowledge and preconceptions.

3. Confronted with the large amounts of new information characteristic of the school environment, many students will simply not process the information at all (e.g., taking no notes or trying to underline or take down everything) or, at most, will assimilate only that information which fits easily into their existing preconceptions.

What follows is a sampling of some of the teaching techniques which are implied by these general principles.

Techniques Which Permit Thinking

1. Structure your assignments in such a way as to explicitly relate all new information, from lectures or readings, to the set of questions or purposes for which that material is assigned (as opposed to simply saying, "read the chapter") - so that students are provided with some structure which will permit them to efficiently organize and store the new information they are to master.

Techniques Which Require Thinking

1. Require students to process new information by requiring them to "transform" it in visible ways rather than simply committing it to memory in its original form. Some techniques for doing this, listed to illustrate increasing amounts of transformation, might include the following.

-Paraphrasing - which requires the translation of new information into the student's own words.

-Underlining or directed reading and notetaking, organized around questions specified in advance of the reading - both of which require at least the selection of information from a larger body of information.

-Summarizing - which requires both the selection of information from a larger body of information and some independent judgments on what is central or crucial.

-Outlining around the structure of the author's argument - which requires, in addition to the above, an understanding of the logical structure of that argument.

-Outlining around a specified set of questions or purposes that are different than those of the author - which requires fashioning a new logical structure.

-Extracting a general principle from more specific pieces of information or experiences -

which requires the additional element of movement from the more concrete to the more abstract.

2. Require students to process new information, at any of the levels of difficulty just described, but in such a way as to bring that information to bear directly on their existing preconceptions. Techniques for doing that might include the following.

-Teasing out students' own views on a subject, as a prelude to presenting new information on it, and then asking them to reconcile the two.

-Asking students to sort through new information, in areas where they have no previous knowledge or preconceptions, in such a way as to develop and publicly defend a view of their own.

3. Consistently reinforce student willingness to approach new information in the more difficult ways just described (rather than by simply memorizing isolated facts) by appropriate modifications of graded exercises and expected classroom performance. This might involve, for example:

-Letting students know in advance that you will call on them in class for succinct public presentations of suitably transformed new information, while you breathe on the tops of their bowed heads.

-Constructing multiple choice exams which require several steps to arrive at the answer; moving from multiple choice to short answer exams; moving from short answer exams to more complex written products - as the primary basis for student grades.

CREATIVITY: GENERATING NOVEL IDEAS

General Principles

As indicated earlier in this report, we know very little about where creativity comes from or about how to trigger it. Accordingly, the teaching techniques listed in this section deal only with methods which might <u>permit</u> students to experience this most important and most mysterious part of the thinking process.

While classroom atmosphere and general curricular structure may be crucial to encouraging creative thought in students, most of the current instructional approaches are focused on systematic approaches to problem solving. Almost without exception, they agree on three necessary, if not sufficient, preconditions to creative thought.

1. Generally delaying premature closure on a single perspective or approach to a problem, and hence creating at least the opportunity for a novel perspective or approach to emerge.

2. A strong metacognitive or "executive" ability in which the thinker is conscious of his/her own thought processes and hence can engage in a systematic consideration of a variety of perspectives or approaches to a problem.

3. For data-based areas of inquiry, a strong knowledge base - including a great deal of accessible information and a repertoire of strategies for manipulating that information.

Techniques Which Permit Thinking

There is also a remarkable degree of agreement in the literature on creativity, problem solving, and metacognition on the procedures which might help students to prevent premature closure and encourage them, instead, to undertake a systematic consideration of a variety of perspectives and approaches. Almost all of those who write on this subject recommend some variant of the following steps.

1. Understand the problem, i.e., the unknown/goal state, the data/initial state, and the conditions/permissible operations.

2. Draw diagrams - to help hold all known information and interrelationships in the short term memory.

3. Relate the problem to what you already know. In writing, this includes such pre-writing exercises as listing ideas, or reviewing all that you know on a topic. In math and science, this might include:

   -Drawing inferences from the initial and goal states and reformulating the problem in light of them.

-Solving analagous but known or simpler problems.

-Breaking the problem down into simpler subproblems and solving those.

4. Conduct a systematic search for a solution by:

-Undertaking an exhaustive search of all logical possibilities (by means of a matrix or computer search).

-Undertaking a restrictive search of likely solutions or of various types of solutions.

-Developing a way of measuring closeness to the goal (an "evaluation function") and taking those steps which move you closer to that goal ("ends-means analysis").

-Working from the goal backwards.

5. Conduct a random search for new ideas, by means of such techniques as "brainstorming" and "attribute listing."

6. Monitor the thought processes involved in all of the above by "thinking aloud" and subjecting your thought process to scrutiny by yourself and others.

DEDUCTION AND TESTING: CONSTRUCTING AND EVALUATING HYPOTHESES AND ARGUMENTS

General Principles

As indicated in the body of this report, most of the mistakes identified in controlled experiments with human reasoning derived less from a general inability to think logically than from two specific sources.

1. The power of preconceptions and the resulting failure to consider opposing viewpoints and the tendency to reject conclusions which follow logically, if they conflict with personal experience or preconceptions.

2. Failure to define terms and formulate arguments with precision.

Techniques Which Require Thinking

The most popular technique for helping students to develop reasoning skills is the Socratic method of questioning and guided discussion. It has several advantages over the dominant alternative approach of lectures, assigned readings, and the evaluation of written student responses to both.

1. It is less threatening and more motivationally engaging for students, because it permits them to build initially on the basic oral competence which almost all students possess.

2. It allows the teasing out of student preconceptions and insures that students will have to review those preconceptions in light of opposing points of view.

3. It is interactive and hence permits the teacher to ascertain students' intended meanings with greater clarity.

4. It permits early intervention by the teacher before students invest a great deal of time in possibly flawed written products.

5. It permits the teacher (and other students) to provide detailed guidance in a relatively short period of time on the global issue of logical coherence which (unlike correcting mistakes in grammar) would otherwise require extended written commentary.

6. It is an excellent form of pre-writing exercise for expository writing - which requires attention to logic, evidence, and precision in expression and which is the type of writing most likely to be required of students both before and after graduation.

VII. REFERENCES

These References, like the report itself, are designed for readers seeking a quick overview of the field of thinking skills. They focus, as a result, on works which themselves provide readily digestible overviews of parts of that field, and on a few influencial works in each area. They are not intended to provide a comprehensive listing of the literature in these large and growing areas of instructional work.

1. A good summary of current research in cognitive psychology and related areas on the thinking process is R. Mayer, Thinking, Problem Solving, Cognition (New York: W. H. Freeman, 1983).

2. This categorization of instructional programs, and indeed the entire Task Force report, owes a great deal to Raymond S. Nickerson, et al, The Teaching of Thinking (Hillsdale, NJ: Lawrence Erlbaum Associates, 1985), and to the generosity of Professor Nickerson in sharing unpublished material with the chairmen of the Task Force. Two other good overviews of instructional programs are: J. Segal, et al, Thinking and Learning Skills: Relating Research to Instruction (Hillsdale NJ: Lawrence Erlbaum Associates, 1985) and "Thinking Skills in the Curriculum," Educational Leadership, Vol. 42, No. 1 (September, 1984).

3. A good general review of Piagetian programs is R. Fuller, et al, Piagetian Programs in Higher Education (Lincoln, NE: ADAPT Program, 1980). For the same argument applied to the pre-college level, see J. Renner and D. Stafford, Teaching Science in Secondary School (NY: Harper and Row, 1972).

4. The problem-solving literature is very large. There are, however, a few classic texts from different fields which might provide a starting point. In mathematics, see G. Polya, How to Solve It (NY: Doubleday, 1957). In computer science, see

A. Newell and H. Simon, Human Problem Solving (Englewood Cliffs NJ: Prentice-Hall, 1972). For a broad-gauged treatment, see J. Hayes, The Complete Problem Solver (Philadelphia: Franklin Institute Press, 1981).

5. Critical thinking textbooks are legion. An early and influencial example is M. Beardsly, Thinking Straight (Englewood Cliffs, NJ: Prentice-Hall, 1975). For a careful analytical treatment, see S. Toulmin, The Uses of Argument (Cambridge, England: Cambridge University Press, 1958), and S. Toulmin, et al, An Introduction to Reasoning (NY: Macmillan, 1979).

6. There are two arch enemies of sloppy thinking who have been at it for a long time. For a very broad approach, grounded in philosophy and dealing with questions of both critical thinking and systematic thinking, see the works of M. Lipman, and in particular, Philosophy in the Classroom (Philadelphia: Temple University Press, 1980); see also the works of A. Whimbey, for example, Problem Solving and Comprehension (Philadelphia: Franklin Institute Press, 1979). In addition, see B. Bloom and L. Broder, The Problem Solving Process of College Students (Chicago: University of Chicago Press, 1950).

7. For an overview of attempts to explain the connections between writing and thinking, see L. Gregg and E. Steinberg (eds.), Cognitive Processes in Writing (Hillsdale, NJ: Lawrence Erlbaum Associates, 1980). For the relationship of writing to complex thought, see D. Olson, "Culture, Technology, and Intellect," in L. Resnick (ed.), The Nature of Intelligence (Hillsdale, NJ: Lawrence Erlbaum Associates, 1976). On the more general questions of the relationship between language and thinking, see L. Vygotsky, Thought and Language (Cambridge, MA: M.I.T. Press, 1962).

8. There is a very large number of cognitive process programs. For a look at two of the better known ones, see R. Feuerstein, Instrumental Enrichment (Baltimore: University Park Press, 1980) and M. Meeker, The Structure of Intellect (Columbus, OH: Charles E. Merrill, 1969).

9. The belief that proficiency in thinking skills will be increasingly important outside educational institutions, and should therefore be emphasized inside them, is a common theme in virtually all of the recent national reports on the future of higher education. See, for example, the National Institute of Education's Involvement in Learning (1984); the Association of American Colleges' Integrity in the College Curriculum (1985); and the Carnegie Foundation for the Advancement of Teaching's Higher Education and the American Resurgence (1985).

10. For a good collection of papers on this subject, see R. Anderson, et al (eds.) School and the Acquisition of Knowledge (Hillsdale, NJ: Lawrence Erlbaum Associates, 1977). For an introductory text, see J. Bransford, Human Cognition (Belmont, CA: Wadsworth, 1979).

11. The best known argument to this effect is R. Reich, The Next American Frontier (New York: Times Books, 1983). See also L. Thurow, The Zero-Sum Society (New York: Basic Books, 1983).

12. See B. Bluestone and B. Harrison, The Deindustrialization of America (New York: Basic Books, 1982), and M. Carnoy and D. Shearer, Economic Democracy (White Plains, New York: Sharpe, 1980).

13. See the description of two sophisticated and carefully evaluated attempts to raise IQ in R. Nicherson, et al, The Teaching of Thinking, (Hillsdale, NJ: Lawrence Erlbaum Associates, 1985), 39-42.

14. An early and optimistic review of attempts to teach intelligence is A. Whimbey, Intelligence Can Be Taught (New York: E.P. Dutton, 1975). For a look at the work of a current leader in the study of intelligence, see R. Sternberg, Beyond IQ (New York: Cambridge University Press, 1984). For a good overview of various conceptions of intelligence, see L. Resnick, (ed.) The Nature of Intelligence (Hillsdale, NJ: Lawrence Erlbaum Associates, 1976).

15. For the limitations on the degree to which practice in specialized subskills will transfer to more general thinking and academic performance, see the review of the effectiveness of "Cognitive Operations" instructional programs in R. Nickerson, et al, Teaching Thinking (Hillsdale, NJ: Lawrence Erlbaum Associates, 1985), 147-189.

16. For overviews of recent research indicating that many thinking skills require a strong knowledge base in the content area, see J. Greeno, "Trends in the Theory of Knowledge for Problem Solving," in D. Tuma and T. Reis (eds.), Problem Solving and Education (Hillsdale, NJ: Lawrence Erlbaum Associates, 1980), 9-23, and R. Glaser, "Education and Thinking," American Psychologist, vol. 39, no.2 (February, 1984), 93-104.

17. The classic works on the acquisition of language are Chomsky's. See N. Chomsky, Syntactic Structures (The Hague: Moulton, 1957), and Language and Mind (New York: Harcourt, Brace, Jovanovich, 1968).

18. For overviews of the research, see R. Nisbet and L. Ross, Human Inference (Englewood Cliffs, NJ: Prentice-Hall, 1980), and A. Tversky and D. Kanneman, "Judgement Under Uncertainty," Science, vol. 125 (1974), 1124-1131.

19. See A. Schoenfeld, "Teaching Problem Solving Skills," American Mathematical Monthly, vol. 87, no.10, 794-805; and A. Schoenfeld, "Problem Perception and Knowledge Structure in Expert and Novice Mathematical Problem Solvers," Journal of Experimental Psychology, vol.8, no.5, 484-494.

20. For an overview of the literature, see K. Feldman and T. Newcomb, The Impact of College on Students (San Francisco: Jossey-Bass, 1973). For the developmental process by which closed minds can be painfully opened, see W. Perry, Jr., Forms of Intellectual and Ethical Development Among College Students (New York: Holt, Rinehart, and Winston, 1970). For a summary of an on-going national

survey of college student attitudes, see Alexander Astin, Four Critical Years (San Francisco: Jossey-Bass, 1983).

21. For an overview of the impact of science and materialism on pre-industrial cultures, see W. Daly, "Ideological Dogmatism", Et Cetera, vol 34, no.1 (March 1977), 43-53. For an overview of the literature on that process in Europe, see Robert Nisbet, The Sociological Tradition (New York: Basic Books, 1966). Some classic analyses of the same process in the non-Western world include, R. Redfield, The Primitive World and Its Transformations (Ithaca: Cornell University Press, 1953); L. Doob, Becoming More Civilized (New Haven: Yale University Press, 1960); and Daniel Lerner, The Passing of a Traditional Society (Glencoe: The Free Press, 1958).

22. For overviews of the literature, see W. Daly, The Revolutionary: A Review and Synthesis (London: Sage, 1972) and N. Smelser, Theory of Collective Behavior (NY: Free Press, 1963).

23. For overviews of the research findings, see R. Mansfield and T. Busse, "The Effectiveness of Creativity Training," Review of Educational Research, vol. 40, no. 4 (1978), 517-536; and E. Torrance, "Can We Teach Children to Think Creatively?" Journal of Creative Behavior, vol. 6, no. 2 (1972), 114-143.

24. See the review of the literature in R. Nickerson, et al, The Teaching of Thinking (Hillsdale, NJ: Lawrence Erlbaum Associates, 1985), 86-100.

25. For a summary of Piaget, see J. Flavell, Cognitive Development (Englewood Cliffs, NJ: Prentice-Hall, 1971). For a revisionist review, see J. Bruner, Toward a Theory of Instruction (Cambridge MA: Harvard/Belknap Press, 1975).

26. The best short overview of current practices in the schools is B. Bayer, "Improving Thinking Skills," Phi Delta Kappan, vol. 66, no. 1 (March, 1984), 486-490.